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Effects of Furrow Irrigation on Corn in the Humid Sub-tropical Mississippi Delta

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Abstract

Corn (*Zea mays* L.) production in the Mississippi Delta has nearly doubled since 1990 but is more susceptible to aflatoxin and fumonisin contamination when grown under drought. Four corn hybrids -- two *Bt* and two non-*Bt* -- were grown at Stoneville, MS under irrigated and non-irrigated treatments in 1999, 2000, and 2001. Furrow irrigation was applied at a rate of 1 inch per application during growth stages R1, R3, and R5 in 1999, R1 in 2000, and R1 and R3 in 2001. Irrigation increased grain yields in 2 out of 3 years. More irrigation treatments in 2000 and 2001 would have likely benefited yields. Yields in 2000 were lower than comparable treatments in 1999 and 2001 due to less weight per kernel indicating drought stress occurred during later reproductive growth (R4 to black-layer). Kernel weights were generally higher in both irrigated and non-irrigated treatments in 2001 than they were in 1999 or 2000. This compensated for having fewer kernels per ear, which likely resulted from drought stress at growth stage V12 in 2001. Differences in test weights were observed among years but not irrigation treatments. The *Bt* hybrids did not differ from the non-*Bt* hybrids in yield or mycotoxin levels. Aflatoxin and fumonisin contamination did not differ among years or irrigation treatments. Levels were below maximum acceptable concentrations for both mycotoxins. The hybrid N79-L3 had significantly lower fumonisin levels than the other hybrids.

Introduction

The importance of sufficient amounts of water (H_2O) to corn (*Zea mays* L.) growth and development is well documented. Though H_2O is the most abundant compound on earth, an H_2O deficit is the single most limiting factor in crop production worldwide (3). Corn can become drought stressed rather quickly during reproductive growth when exposed to environments of high ambient temperature and low relative humidity. Research on early corn hybrids showed grain yield reductions of more than 50% when brief periods of wilting were encountered at anthesis (6,22). Hanway (10), estimated the average daily H_2O use from silking to the soft dough stage of kernel development by hybrids grown during the 1950s was 0.25 to 0.30 inch per acre per day. Duvick (9) demonstrated that newer corn hybrids produced during the early 1980s when grown under drought and heat stress were superior in grain yield compared to older hybrids.

Compared to other crops, corn is more efficient in H_2O use (11). Corn and other C4 crop species have nearly a 2-fold higher water use efficiency (WUE) than C3 species (3). In environments of high light intensity and temperature, the higher WUE is due mainly to higher rates of photosynthesis by C4 crops, which results in more dry matter (DM) production. Under low light levels the higher WUE is due to lower transpiration rates. However, because corn produces larger quantities of DM per acre than most other crops, drought stress can occur quickly, especially during reproductive growth. Water loss in cornfields is primarily by surface evaporation from bare soil during early vegetative growth but shifts to evapotranspiration as the tassel begins to emerge and reproductive growth begins (24).

Corn production in the Mississippi Delta has more than doubled in the past 10 years from 397,670 acres grown in Arkansas, Louisiana, and Mississippi in 1990 to 944,775 acres in 2000. Average yields for the region have improved from 95.7 to 129.2 bu/acre during the same time frame (17). Changes in government farm programs, interest in alternatives to continuous cotton (*Gossypium hirsutum* L.) production, and rising demands for corn grain by local poultry and commercial channel catfish [*Ictalurus punctatus* (Rafinesque)] growers have all contributed to increased corn production.

Some corn germplasm is now being modified through transgenics to impart insect resistance to commercially grown hybrids. The introduction of *Bacillus thuringiensis* (*Bt*) into some corn hybrids is helping reduce the use of chemical insecticides for control of certain Lepidopteran species (5). Several Lepidopteran corn insect pests have been identified as contributing to increased levels of aflatoxin, a mycotoxin produced by *Aspergillus* spp. fungi (7,14,28)

Mississippi Delta corn producers experienced extensive economic losses during 1998 due to infection of the grain by *Aspergillus* spp. fungi, which were aided by heat and drought stress during the crop's reproductive growth. Aflatoxins, a secondary product of *Aspergillus* spp., are known to cause a number of diseases in humans and livestock (4). Drought stress has been shown to also facilitate the production of aflatoxin (13). A reduction in *Aspergillus flavus* infection and aflatoxin concentration were observed in irrigated corn compared to grain produced with no irrigation (12). An even greater contrast in these differences was noted during a season of below normal rainfall.

Fumonisins are another class of mycotoxins produced by fungi of the *Fusarium* spp. Like aflatoxins, fumonisins are known to contaminate corn grain and cause human and animal disease (15,18,25). Payne (20) stated that conditions favorable to the production of fumonisin are not fully known. He concluded the fungi can grow over a broad range of environmental conditions but appear to be favored by heat and drought. A later U.S. FDA (26) report states that fumonisin levels in raw corn are favored by environmental conditions of heat and drought stress followed by periods of high humidity.

Most corn production in the Mississippi Delta utilizes irrigation to alleviate drought stress that almost always occurs in the region during kernel filling. However, not all corn crops in the area are irrigated in a timely manner or may not be irrigated at all because of the lack of a water source, irrigation equipment, or mechanical failure of the equipment at a critical time. The most common method of irrigation in the region is furrow irrigation with the first application of water at silking (growth stage R1) and water applied every 10 days thereafter or 10 days after a rain event of 1.00 inch or more. Information about the effects of irrigation on currently popular corn hybrids in the Mississippi Delta is limited, with basically no data comparing *Bt* and non-*Bt* hybrids. The corn-growing season in this region is such that all reproductive growth occurs as rainfall events are diminishing and ambient temperatures are increasing. These environmental conditions are favorable to aflatoxin contamination of the grain. This experiment was designed and conducted to ascertain the effects of irrigation on grain yield, yield components, and mycotoxin production of corn hybrids currently being produced in the Mississippi Delta.

Irrigation Studies with Four Hybrids

The study was conducted at the Mississippi State University Delta Branch Experiment Station at Stoneville, MS in 1999, 2000, and 2001. Soil at the experimental site was a Beulah fine sandy loam (coarse-loamy, mixed thermic Typic Dystrochrepts). Soil samples were acquired each year prior to planting and supplemental fertility needs ascertained. The previous crop at the site all three years was corn.

Two *Bt* corn hybrids (Syngenta NK brand cv. N79-L3Bt and Pioneer brand cv. 33Y09Bt) and two non-*Bt* corn hybrids (Pioneer brand cv. 32K61 and cv. 3223) were planted at the site on 1 April 1999, 21 April 2000, and 21 April 2001. Planting was done at a seeding rate of 27,500 plants per acre with an expected final population of approximately 23,500 plants per acre in rows spaced 40 inches apart. Experimental design was a randomized complete block with a split-plot arrangement of treatments replicated five times. Whole plots were either irrigated or non-irrigated treatments. Sub-plots were the hybrids, which were randomly arranged within each whole plot. The experiment was repeated three years in the same field but in different locations within the field and a new randomization of whole plots and sub-plots applied each year. Individual sub-plots were four rows, 30-ft long. Non-irrigated buffer strips consisting of four rows of the hybrid 3223 were planted between and parallel to all irrigated and non-irrigated treatments.

Prior to planting, K as muriate of potash at 60 lb/acre and N as NH_4NO_3 at 100 lb/acre were applied and incorporated into the soil. Additional N in a liquid fertilizer form at 90 lb/acre was applied at growth stage V6, as defined by Ritchie et al. (21). Weed control was accomplished by a pre-emergence application of Bicep (atrazine + metolachlor at 2.0 and 1.5 lb/acre ai, respectively) (Monsanto; St. Louis, MO). Irrigation treatments were applied after anthesis, using furrow irrigation and a schedule commonly used for corn production in the region, which is a 10-day rotation between irrigations or after a rain event of 1.00 inch or more after silking. It is estimated that approximately 1.00 inch of water gets applied to most soils in the Mississippi Delta using this irrigation system. Irrigation was applied 14 June 1999 during growth stage R1 (silking), 25 June 1999 during growth stage R3, and 8 July 1999 during growth stage R5. During the second year of the experiment, one irrigation was applied during growth stage R1 on 12 June 2000. In 2001, irrigation was applied during growth stage R1 on 19 June 2001 and on 9 July 2001 during growth stage R4.

Final plant populations were determined by counting tasseled stalks in the center 17 ft of the two center rows of each sub-plot. The end plants of each of the counted rows were marked with fluorescent flagging tape. Prior to harvest these same areas were inspected and the number of lodged plants and dropped ears recorded. Ears of the marked plants and those in-between were hand harvested approximately 21 days after growth stage R6 (black-layer). Ear weight of each sub-plot was determined and the ears shelled using a gasoline powered stationary Almaco corn sheller (Allen Machine Co., Nevada, IA). Grain was weighed and samples taken to determine grain moisture content at shelling, kernel weight, and mycotoxin contamination in 1999. Grain samples acquired in 2000 and 2001 were also used to determine grain test weight. Instrumentation for determining grain test weight was unavailable to us prior to 2000. Sub-plot grain weights and calculated yields were adjusted to 15.5 % moisture. Kernel weights were determined by hand-counting 100 sound kernels from each sub-plot and weighing the samples. The average number of kernels per ear was calculated using data on plant populations, grain weights per sub-plot, and kernel weights. Data from the sub-plot ear weights and grain weights were used to calculate shelling percentage.

Aflatoxin and fumonisin contamination was determined by grinding a 0.5 lb grain sample from each sub-plot to pass a 2 mm screen and testing it using Veratox-Aflatoxin Kits and Veratox-Fumonisin Kits (Neogen Co., Lansing, MI). Procedures for the tests are outlined by Abouzied et al. (2) and Abbas et al. (1). Statistical analyses were preformed for a split-plot using a system for combining experiments as outlined by McIntosh (16). Years were treated as a fixed effect and Satterthwaite's Approximation for the degrees of freedom was specified in the PROC MIXED procedure, SAS Institute (23).

Irrigation, Grain Yield, and Mycotoxin Production

Data on plant populations show that over the entire experiment the expected population of approximately 23,000 plants per acre was achieved in all treatments in 2000 and 2001 but not in 1999. During that year, the hybrid N79-L3Bt, in both irrigated and non-irrigated treatments, achieved an average final plant population of about 25,000 plants per acre. The Pioneer hybrids in 1999 had final plant populations of about 23,000 plants per acre. No other significant differences in plant populations were observed among any of the other hybrids, treatments or years of the experiment. The high plant populations of N79-L3Bt in 1999 are partly responsible for the high grain yields observed for that hybrid that year when compared to yields of the other hybrids and subsequent years (Table 1).

Table 1. Corn grain yields[x] (bu/acre) of four hybrids grown under irrigated (I) and non-irrigated (NI) conditions at Stoneville, MS in 1999, 2000, 2001.

Hybrid	1999[y]		2000[y]		2001[y]	
	I	**NI**	**I**	**NI**	**I**	**NI**
N79-L3Bt	216.4	186.3	151.2	144.1	158.5	157.1
33Y09Bt	193.9	177.9	160.4	161.1	172.6	165.1
3223	173.8	154.5	155.1	155.7	194.2	160.1
32K61	177.6	162.1	154.9	146.5	172.2	154.5
Average[z]	190.4	170.2	156.9	151.7	174.4	159.2

[x] Averages of 5 replications.

[y] Averages within a year LSD (0.01) = 31.8 and among years LSD (0.01) = 33.5.

[z] Averages within a year LSD (0.01) = 15.2 and among years LSD (0.01) = 18.9.

Irrigation resulted in significantly ($P < 0.01$) higher average grain yields in 1999 and 2001 (Tables 1 and 2). Grain yields in 2000 though did not differ significantly between irrigated and non-irrigated treatments and were generally low compared to comparable treatments in the other two years. Official precipitation and accumulated degree days above 50°F adjusted for day length acquired at the National Weather Service, Cooperative Weather Network Site at Stoneville, MS, approximately 0.5 mile from the experimental site, are presented in Table 3 (8). These data are reported to correspond to the occurrence of various growth stages in corn as described by Ritchie, et al. (21). Both irrigated and non-irrigated plots in 2000 received 3.5 and 1.7 more inches of rain between silking and growth stage R3 than plots in 1999 and 2001, respectively. A major rain event totaling 2.0 inches occurred 29 June 2000 delaying the next irrigation to at least 9 July 2000. However, by that date the irrigation equipment was being used extensively for other research. Thus, the decision was made to forego any further irrigations of the experiment in 2000. Drought stress most likely occurred between growth stage R3 and black-layer in the irrigated plots in 2000 negating the benefit of the early irrigation and demonstrating the importance of continued irrigation despite the total amount of rain received in any given precipitation event.

Table 2. Combined analysis of variance of grain yields for four corn hybrids (Pioneer 3223, 33Y09, 32K61, and Syngenta NK N79-L3) grown either with or without furrow irrigation at Stoneville, MS in 1999, 2000, and 2001.

Source	**Num df**[y]	**Den df**[z]	**F value**	**P>F**
Year	2	12	9.69	0.0031
Irrigation	1	84	14.62	0.0003
Year × Irrigation	2	84	1.55	0.2174
Hybrid	3	84	1.88	0.1394
Year × Hybrid	6	84	4.32	0.0008
Irrigation × Hybrid	3	84	0.21	0.8923
Year × Irrigation × Hybrid	6	84	0.79	0.5833
ERROR			**Components of error**	
Reps (Year)		12	40.29	
Residual		84	376.22	

[y] Num df, numerator degrees of freedom.

[z] Den df, denominator degrees of freedom.

Table 3. Dates of various growth events, accumulated degree days above 50°F average, and inches of total water received between events of corn grown using furrow irrigation at Stoneville, MS in 1999, 2000, and 2001.

1999			
Event	**Date**	**Accumulated DD50**[x]	**Inches**[y]
Planting	4/1	0	0
Silking	6/4	1419	11.9
R2	6/15	1767	1.2[z]
R3	6/22	1951	0
R4	6/30	2199	3.4[z]
R5	7/6	2403	0.4
Black Layer	7/12	2591	1.2[z]
		Total Water	18.1
2000			
Event	**Date**	**Accumulated DD50**[x]	**Inches**[y]
Planting	4/21	0	0
Silking	6/12	1434	9.8
R2	6/22	1751	2.7[z]
R3	6/29	1969	2.0
R4	7/7	2222	0
R5	7/12	2396	0
Black Layer	7/16	2546	0
		Total Water	14.5
2001			
Event	**Date**	**Accumulated DD50**[x]	**Inches**[y]
Planting	4/21	0	0
Silking	6/17	1445	7.2
R2	6/28	1755	2.3[z]
R3	7/4	1946	0.7
R4	7/11	2191	1.0[z]
R5	7/18	2398	1.8
Black Layer	7/23	2567	0
		Total Water	13.0

[x] Accumulated Growing Degree Days over 50°F adjusted for day length.

[y] Total inches of water received since pervious event.

[z] Total includes approximately 1 inch of water applied by furrow irrigation.

The reduced grain yields in irrigated treatments, observed in 2000 compared to similar treatments in 1999 and 2001, were due in large part to less weight per kernel (Tables 4 and 5). The lower kernel weights in 2000 further indicate the plants were under some degree of drought stress during the later stages of their reproductive growth. The two inches of rain that fell on the experiment 29 June 2000 was evidently insufficient to avoid drought stress to the crop before black-layer. Though visible signs of drought stress, such as wilting and leaf curling, were not observed, another irrigation approximately 10 days after this rain event would have likely improved the grain yield of the irrigated treatments in 2000.

Table 4. Combined analysis of variance of kernel weights and kernels per ear for four corn hybrids (Pioneer 3223, 33Y09, 32K61, and Syngenta NK N79-L3) grown either with or without furrow irrigation at Stoneville, MS in 1999, 2000, 2001.

Source	Num df[v]	Den df[w]	F value kwt[y]	F value kpe[z]	P>F kwt[y]	P>F kpe[z]
Year	2	12	99.04	54.85	≤0.0001	≤0.0001
Irrigation	1	12	3.85	11.84	0.0733	0.0021
Year × Irrigation	2	12	1.70	4.50	0.2240	0.0219
Hybrid	3	72	5.38	3.91	0.0021	0.0121
Year × Hybrid	6	72	6.83	1.34	≤0.0001	0.2508
Irrigation × Hybrid	3	72	0.07	0.40	0.9781	0.7538
Year × Irrigation × Hybrid	6	72	1.49	1.16	0.1949	0.3396

ERROR	Den df[w]	Components of error kwt[y]	Components of error kpe[z]
Reps (Year)	12	0.4105	0
Rep × Irrigation (Year)	12	0.06633	51.1025
Residual	72	2.1661	2961.61

[v] Num df = numerator degrees of freedom.
[w] Den df = denominator degrees of freedom.
[y] kwt = kernel weight.
[z] kpe = kernels per ear.

Table 5. Kernel weights[x] (mg) of four corn hybrids grown under irrigated (I) and non-irrigated (NI) conditions at Stoneville, MS in 1999, 2000, and 2001.

Hybrid	1999[y] I	1999[y] NI	2000[y] I	2000[y] NI	2001[y] I	2001[y] NI
N79-L3Bt	301	269	258	248	336	357
33Y09Bt	296	289	262	256	341	335
3223	337	321	265	261	334	324
32K61	290	272	247	250	344	334
Average[z]	306	288	258	254	339	338

[x] Average of 100 kernels and 5 replications.
[y] Averages within a column LSD (0.01) = 28 and within a row LSD (0.01) = 32.
[z] Averages within a year LSD (0.05) = 15 and among years LSD (0.05) = 16.

With the exception of the hybrid 3223 in 1999, kernel weights were generally greater in 2001 than the previous two years (Table 5). However, the average number of kernels per ear in all hybrids, except the irrigated treatment of 3223 and the NI treatment for N79-L3Bt in 1999, were significantly lower in 2001 for both irrigated and non-irrigated treatments than for the pervious two years (Table 6). The increase in kernel weights in 2001 compensated for the fewer number of kernels per ear and increased grain yields in most treatments and hybrids, to levels comparable to those observed in 1999 and 2000 (Table 1).

Otegui and Bonhomme (19) stated that the pre-silking environment defines the potential number of kernels per ear set in corn. The average numbers of kernels per ear were greater in 1999 and 2000 than the comparable treatments in 2001 (Table 6). The amount of rainfall received between planting and growth stage R2 was greater in 1999 (12.1 inches) and 2000 (11.5 inches) than in 2001 (8.5 inches) (8). During growth stage V12 the number of florets per ear in corn is being determined (21). A lower amount of rainfall during this period of growth likely occurred in 2001 and thus reduced the number of florets initiated per ear. Further research is warranted to determine if irrigating corn at growth stage V12 will consistently increase the number of kernels per ear and be economically beneficial.

Table 6. Numbers of kernels[x] per ear of four corn hybrids grown under irrigated (I) and non-irrigated (NI) conditions at Stoneville, MS in 1999, 2000, and 2001.

Hybrid	1999[y]		2000[y]		2001[y]	
	I	NI	I	NI	I	NI
N79-L3B	683	511	660	653	563	481
33Y09Bt	696	587	710	652	550	511
3223	673	581	655	693	636	520
32K61	737	612	690	704	587	516
Average[z]	697	573	679	676	584	507

[x] Average of 5 replications.

[y] Averages within a column LSD (0.05) = 68 and within a row LSD (0.05) = 68

[z] LSD (0.01) = 50.

The lack of irrigation in the non-irrigated plots in 1999 and 2001 further reduced the number of kernels per ear by probably reducing both the number of florets fertilized at silking and fertile florets that matured (Table 6). However, the number of kernels per ear in 2000 did not differ between irrigated and non-irrigated treatments. Also the number of kernels per ear in 2000 exceeded those of the non-irrigated plots in 1999 and both irrigated and non-irrigated plots in 2001. Rain events occurred on 17 June 2000 (0.45 inch), 18 June 2000 (0.61 inch), and 19 June 2000 (0.10 inch) which most likely alleviated drought stress during silking and allowed an apparent equal number of fertile florets to develop on ears in both the non-irrigated and irrigated treatments. The previously mentioned drought stress on the irrigated plots in 2000 would have reduced the number of fertilized florets reaching maturity by a magnitude similar to the non-irrigated plots thus helping to eliminate any difference between the treatments. In 2001, although 1.3 inches of rain occurred between silking and growth stage R2, the rain events did not occur until 22 June 2001 (0.2 inch) and 28 June 2001 (1.1 inch) (8). These events evidently did not occur early enough during silking to increase the number of florets fertilized in the non-irrigated treatments. Only 0.2 inches of rain fell on 14 June 1999 which would account for the observed difference in kernel numbers between irrigated and non-irrigated treatments.

The non-irrigated treatments in this experiment evidently experienced some degree of drought stress through out most of the reproductive growth phase. Resulting grain yields were lower for most of these plots compared to the irrigated plots in both 1999 and 2001 (Table 1). Ritchie et al. (21) states that drought stress on corn during 14 days prior to and 14 days after anthesis will cause large grain yield reductions. These data indicate that yield reductions can be severe when moisture becomes limited later than 14 days after silking.

No differences in grain test weights were observed between irrigated and non-irrigated treatments. Grain test weights were significantly ($P < 0.01$) greater in 2000 than 2001 (59.0 versus 56.3 lbs/bu, respectively). Though kernels produced in 2000 were smaller than those produced in 2001, as indicated by less weight per kernel, they evidently were denser. However, grain test weights for both years exceeded the minimum U.S. standards for No. 1 yellow corn grain (26). Significant ($P < 0.01$) differences in grain test weights were noted among hybrids. The hybrids NK N79-L3Bt and 32K61 had similar grain test weights (58.4 and 58.0 lbs/bu, respectively), which were higher than those of 33Y09Bt and 3223 (56.8 and 56.0 lbs/bu, respectively). However, the lowest value (56.0 lbs/bu) was still at the minimum U.S. Standard for No. 1 yellow corn.

Irrigation had no effect on shelling percentage (grain wt per ear/total ear wt × 100). Shelling percentage was significantly ($P = 0.01$) higher in 2000 (89.3%) and 2001 (87.7%) than 1999 (84.3%). No differences in shelling percentage were observed among hybrids.

No one hybrid or pair of hybrids, i.e., *Bt* versus non-*Bt*, was consistently superior or inferior in yield or the measured yield components. Neither were any consistent differences observed among hybrids with respect to their response to irrigation. Selecting high yielding hybrids to grow under irrigation is important in order to maximize economic yield and cover the added fixed cost associated with irrigation.

Aflatoxin was not detected in any grain samples in 2000. In 2001, only one sample was found to be above the U.S. FDA maximum level of 20.0 ppb allowable for commercial trade (27). The maximum amount detected in any sample in 1999 was 11.4 ppb. Combined analysis of data from 1999 and 2001 showed no hybrid or irrigation treatment differences in aflatoxin contamination.

Fumonisin contamination was observed in most grain samples taken throughout the experiment. However, the observed levels were below the U.S.FDA maximum allowable level of 5.0 ppm for livestock feed (26). Fumonisin levels were significantly ($P < 0.05$) higher in 2000 (3.8 ppm) than in 1999 (1.8 ppm). The levels observed in 2001 (2.6 ppm) did not differ significantly from either 1999 or 2000. The hybrid N79-L3Bt was significantly ($P < 0.05$) lower in fumonisin contamination (1.6 ppm) than the other hybrids in the experiment (3.2, 3.0 and 3.1 ppm for 3223, 32K61 and 33Y09Bt, respectively). Irrigation had no effect on fumonisin contamination in this experiment.

Conclusions

Corn grain yields in this study tended to increase with irrigation mainly through increased numbers of kernels per ear. Yield reductions due to a lack of irrigation were not as great with the hybrids used in this study as those reported in earlier research (6,22). Data from this study tends to agree with information presented by Duvick (9), that newer corn hybrids are superior in grain yield to earlier hybrids when grown under drought stress. Fewer differences in kernel weights due to irrigation or hybrids were observed in this experiment than were reported in previous studies (6,22).

Data on yield and kernels per ear indicated the lower amount of rainfall received between planting and silking in 2001, compared to the two previous years, likely resulted in fewer florets being initiated at growth stage V12, resulting in fewer kernels per ear. Based on this finding, it needs to be determined if irrigating corn at growth stage V12 may be economically beneficial. Provided there is adequate soil moisture after silking, the plant will compensate for having fewer kernels by increasing kernel weight, which was observed in 2001. However, this compensatory effect may not be sufficient in preventing a yield loss. Moisture stress during later reproductive growth may cause fewer kernels to mature and/or reduce kernel weights as seen in the results from the study in 2000.

These data also indicate that the total amount of water received in a single rain or irrigation event is not as important to yield as the frequency of these events. A single rain event of more than 1.0 inch does not appear to extend the amount of time beyond 10 days before the crop will need to be irrigated. The decision to apply a final irrigation to corn should not be based on the anticipated date of black layer formation but rather the number of days since the last irrigation or rain event of 1.0 inch or more.

Mycotoxins, both aflatoxin and fumonisin, were not a problem in neither the irrigated nor the non-irrigated treatments of this experiment. Sources of inoculum for natural infection were either low and/or environmental conditions were not conducive to significant infection and subsequent contamination of the grain by either fungal species. Further research will be needed to verify if N79-L3Bt may have some resistance to fumonisin contamination.

Disclaimer

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